Overview of NASA Glenn Aero/Mobile Communication Demonstrations

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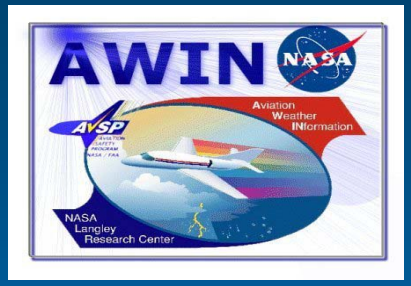
Why Aero/Mobile Demonstrations?

- Requirement to demonstrate emerging and current communication technologies that distribute IP-based services to a mobile platform such as an aircraft or a van.
- Various NASA projects have aviation communication concerns that could be explored with a mobile platform:
  - Advanced Communications for Air Traffic Management (AC/ATM)
  - Aeronautical Satellite Assisted Process for Information Exchange through Network Technologies (Aero-SAPIENT)
  - Aviation Weather Information (AWIN)
  - Weather Information Communications (WINCOMM)
  - Advanced Air Transportation Technologies (AATT)



AC/ATM

Aero-SAPIENT

How did our group go about it?

- Developed a flexible system supporting multiple communication links to an aircraft or ground vehicle that be used as an aviation communication testbed.
- Used COTS hardware, custom software/hardware, IP protocols for mobile and aircraft demonstrations.
- Installed the communication system into GRC's Aero/Mobile van, DFRC's DC8 and LaRC's B757 to support various projects such as AATT, AeroSAPIENT and AC/ATM.
- Used CPDLC, HTTP, ftp, iperf, ttcp, system logging capabilities and other applications to demonstrate the system.

Who was involved?

Information Technology Program
- Ames Research Center (ARC)
- Dryden Flight Research Center (DFRC)
- Creare - Ring Buffer Network Bus

Aviation Safety Program
- Langley Research Center (LaRC)
- Rockwell Collins - Weather/Turbulence

Airspace Systems Program
- Ames Research Center (ARC)
- Boeing - Ku-band Phase Array Antenna
- CNS, Inc - CPDLC
- Dubbs and Severino, Inc - Digital Aviator/Multifunction Display

Glenn Research Center at Lewis Field

AC/ATM
- Free Flight Concepts

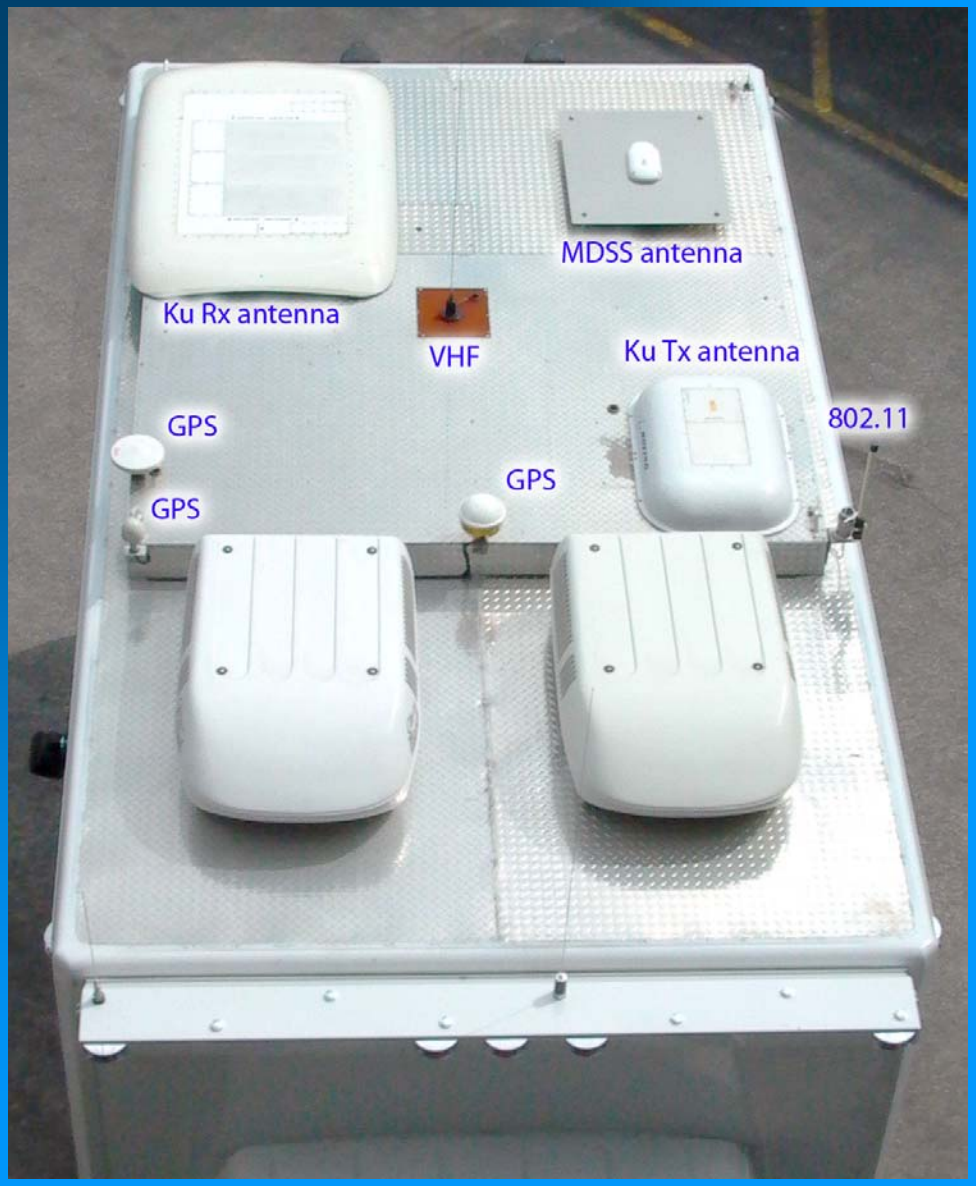
WINCOMM
- Access to weather information.

AeroSAPIENT
- Broadband network connectivity.

GRC Aero/Mobile Van System Overview

GRC Aero/Mobile Van

- Mobile platform started with a single Ku-band satellite link with three more links added over 2002-2003 for ATN and IPv4 connectivity.
  - Ku-band geosynchronous satellite link with a ~2 Mb/s QPSK downlink and a 256 kb/s Spread Spectrum uplink to GRC's Ku fixed station
  - L-band MDSS satellite link to an offsite fixed link providing IP connectivity back to GRC.
  - VHF 19.2 kb/s link to GRC's fixed station.
  - 802.11B (2 -11 Mb/s) connectivity up to 4 bridge points around the GRC campus.
- System is reconfigurable for new capabilities such as:
  - communication links, networking hardware, applications, aviation ...
- Initial test platform before system upload to an aircraft.



Mobile Multilink Demonstration Progression

GRC van's support for multiple communication paths :

- Select between VHF and Ku-band mobile communication paths using static routes on the van's Cisco 3640 router for IPv4 connectivity. (2001-2002)
- Select between VHF and Ku-band mobile communication paths using a weighted routing table on the van's Cisco 3640 router for IPv4 connectivity. (2002-2003)
- Select VHF, Ku-band, L-band and 802.11B mobile communication paths using Mobile IPv4 RFC3344 with NEMO(Networks in Motion) to support a fixed IP subnet using a Cisco 3640 router. (2003-2004)
- Select VHF, Ku-band, L-band and 802.11B mobile communication paths using current IETF draft Mobile IPv6 NEMO using a Cisco 3745. (January 2004-Present)

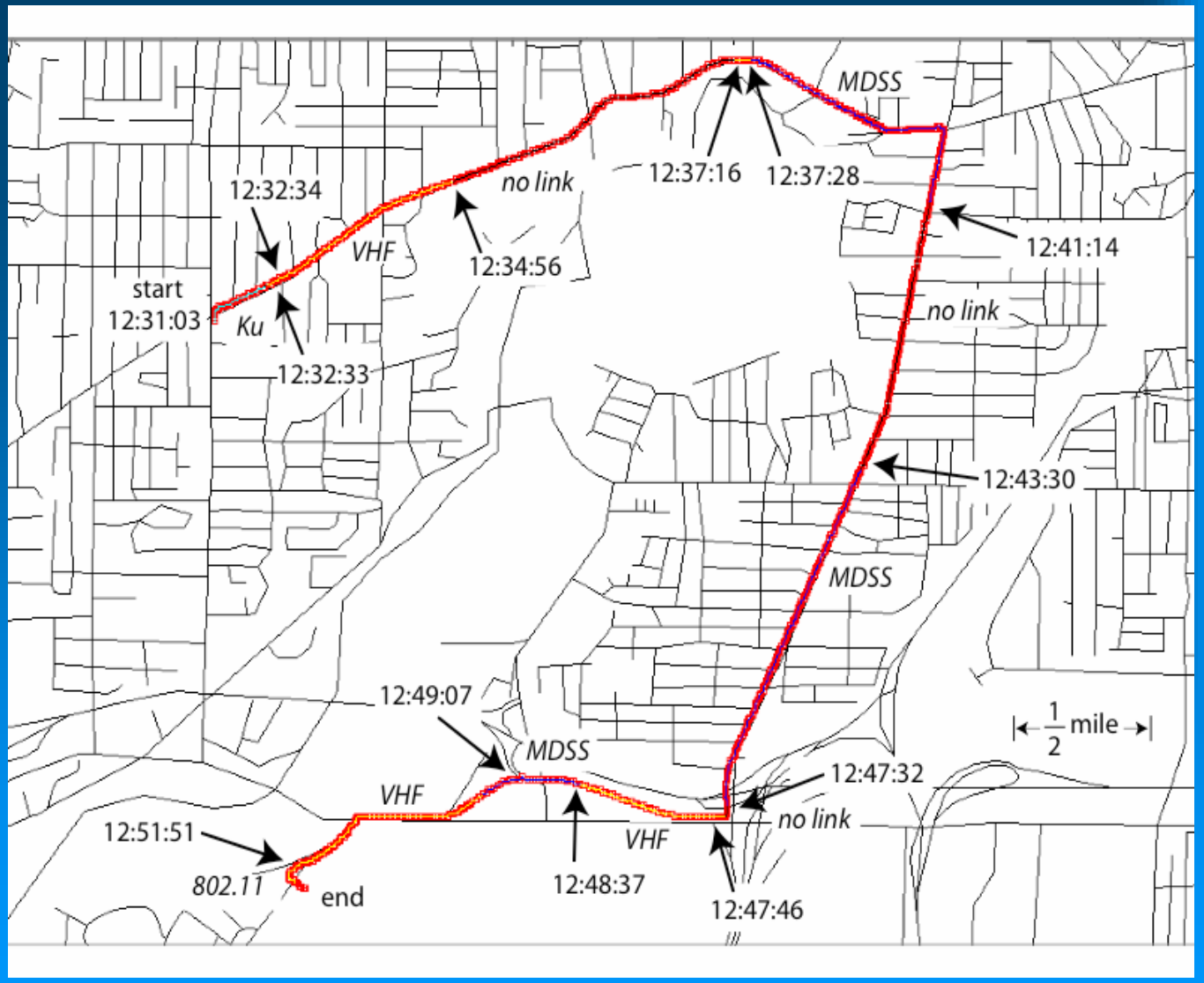
NOTE: Most experiments were conducted while under motion around the GRC campus and northeast Ohio.

What can be demonstrated in the van?

- Ability to record mobile system state information from various devices to a file with microsecond resolution timestamps.
  - The logging system suite is called NASA GRC AATT Logging System(NGALS).
  - NGALS files can be used to correlate network and other system events.
  - NGALS files include attitude, position, router, modem status and other data points.
- Any aviation communication system requiring attitude and position data on an ARINC429 data bus.
  - ARINC429 data is created by combining ring-laser gyroscope data with Global Positioning System(GPS) data on a SUN computer. The combined data is written out a Ballard ARINC429 PCI card for communication system use.
  - Steerable antenna systems require this attitude and position information .
- Any software that can run under Solaris2.x, Windows2000 and OSX on the various van computer platforms.
- Any IPv4 or IPv6 based hardware.
- An opportunity to test aeronautical communication systems without the expense or logistical burden of flight testing

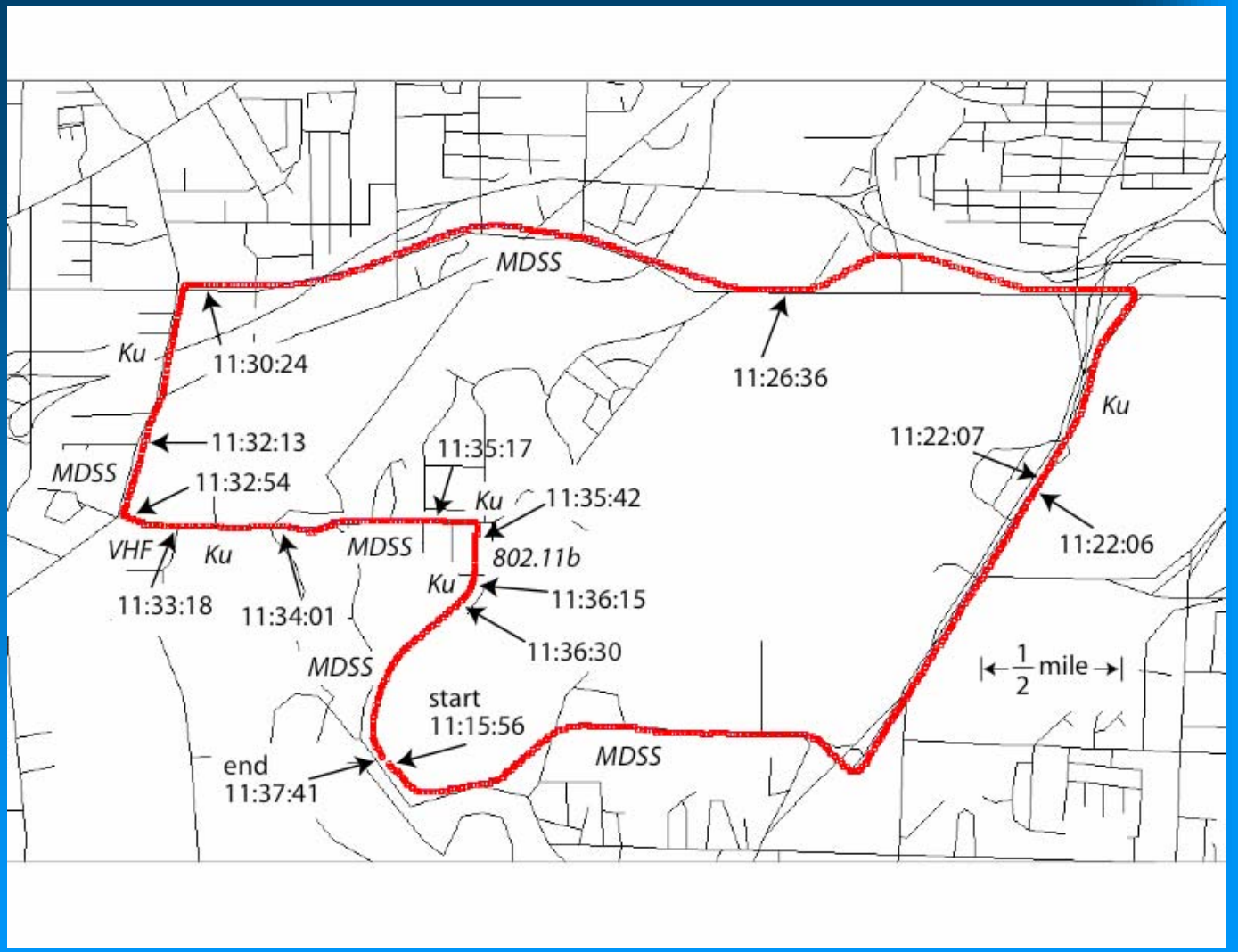
Mobile Platform Multi Link Switchover

- Map of platform link switchovers while driving north of the GRC campus on March 2nd, 2004.
- The map is a 20 minute subset of a 70 minute test.
- Link priority:
  - 802.11B(High)
  - MDSS
  - Ku-band
  - VHF(Low)



Mobile Platform Multi Link Switchover

- Map of platform link switchovers while driving outside the GRC campus on March 2nd, 2004.
- The map is a complete run.
- Link priority:
  - 802.11B(High)
  - MDSS
  - Ku-band
  - VHF(Low)



Mobile Platform Uplink Demonstrations

- AXIS2100 web camera uploads a low resolution jpeg picture to a ground ftp server every minute.
- This demonstrates IP-based telemetry from the mobile platform to a fixed server.

GRC Aero/Mobile Van

GRC Aero/Mobile Van

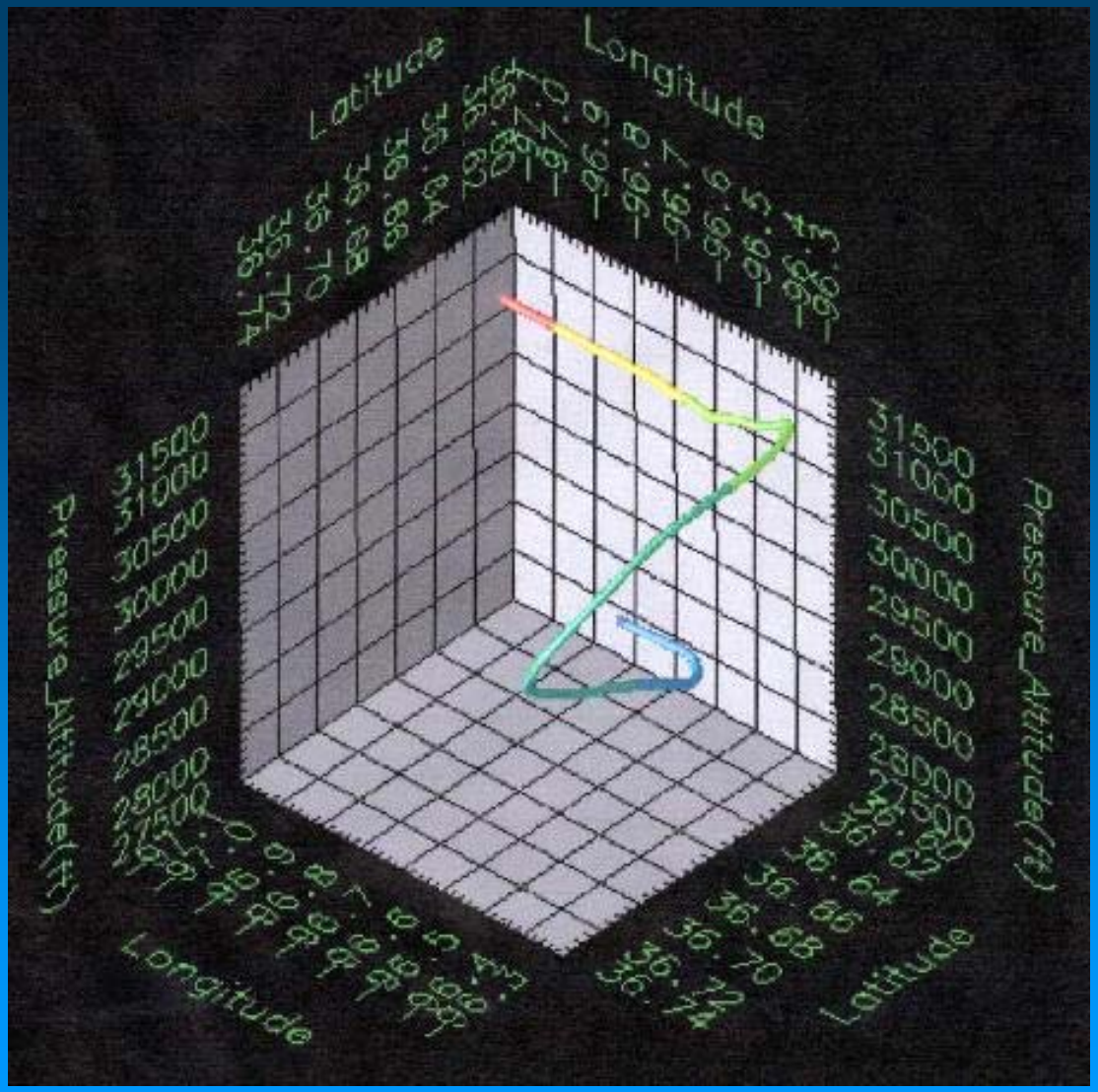
Aviation demonstrations using one bi-directional Ku-band link

NASA DFRC's DC8 for AeroSAPIENT

DC8 flights near Tinkers AFB in Oklahoma (11/28/2000 through 12/11/2000)

- Provided GRC and DSFC IP connectivity for the AeroSAPIENT project.
- Achieved 256 kb/s transmit from, and 2.1 Mb/s receive, between NASA DC-8 and GRC, DFRC, and ARC using the Ku-band phase array.
- Used a SUN computer as a IP router to support various simultaneous applications (intra/internet) on the link.
  - VoIP (voice), FTP (file transfer), TTCP (capacity test tool), E-mail, HTTP (web browsing, weather access, web server provided DC-8 Digital Air Data System), CPDLC (ATN app), Sun Forum (duplex video, white boards, text) and SSH (secured remote access) used by GRC.
  - Ring Buffered Network Bus (Java middleware, cache management, stream proxy services) and Authentication (PKI) used by DFRC.
- Sustained connectivity except in extreme conditions due to INS refresh issues.

Severe Flight Profile

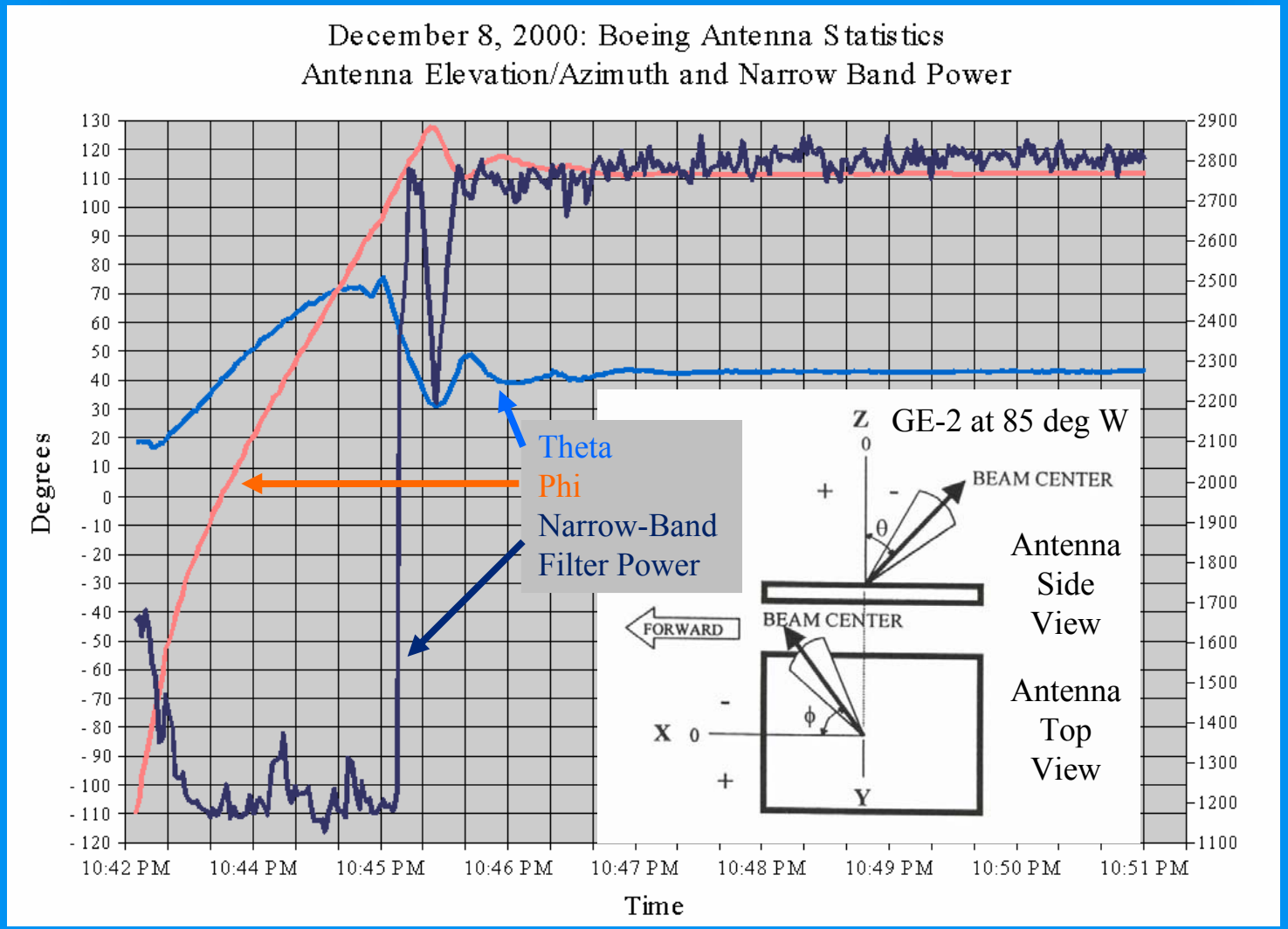


Dec 8, 2000

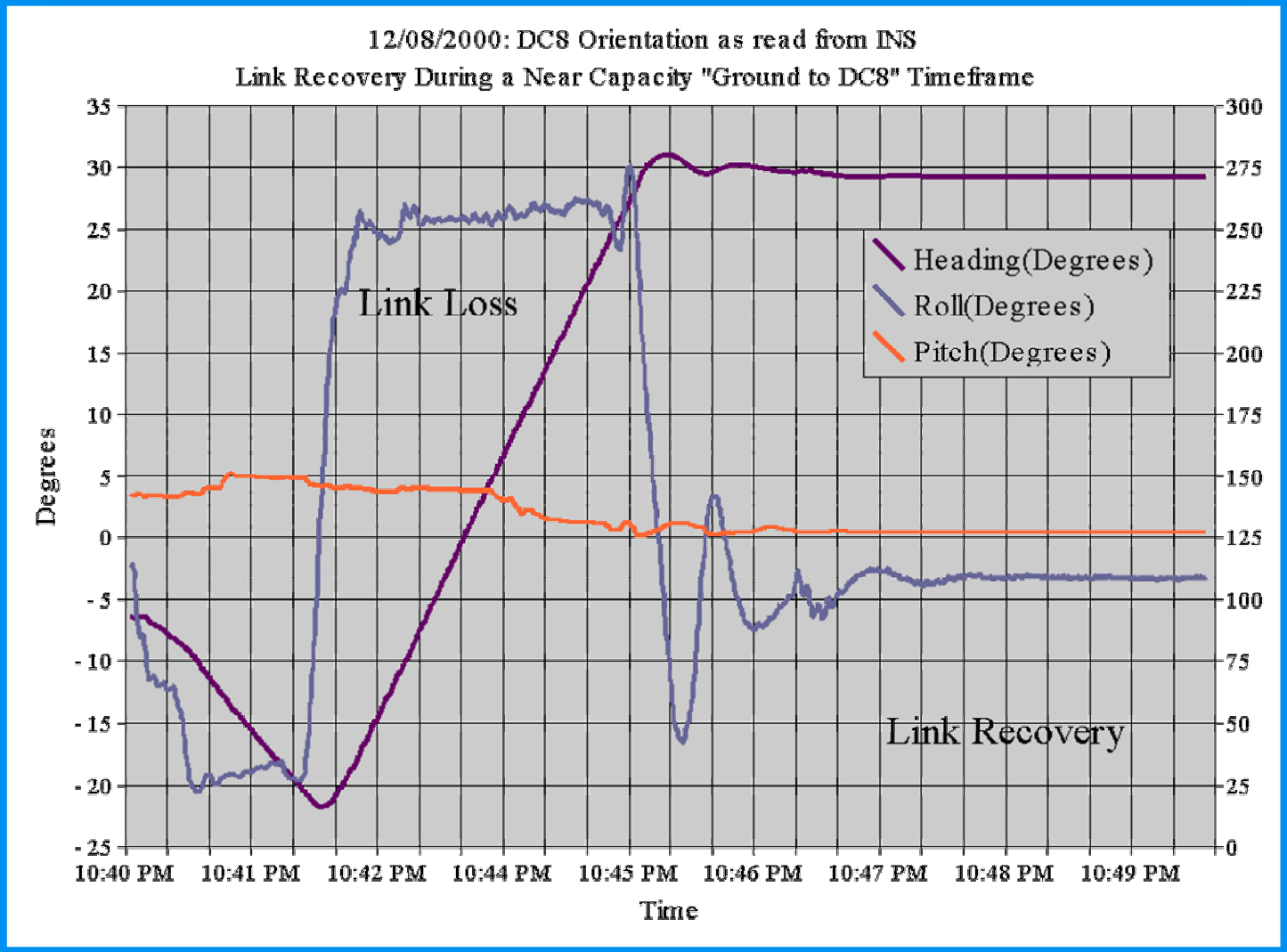
Red = 10:50pm

Blue = 10:40pm

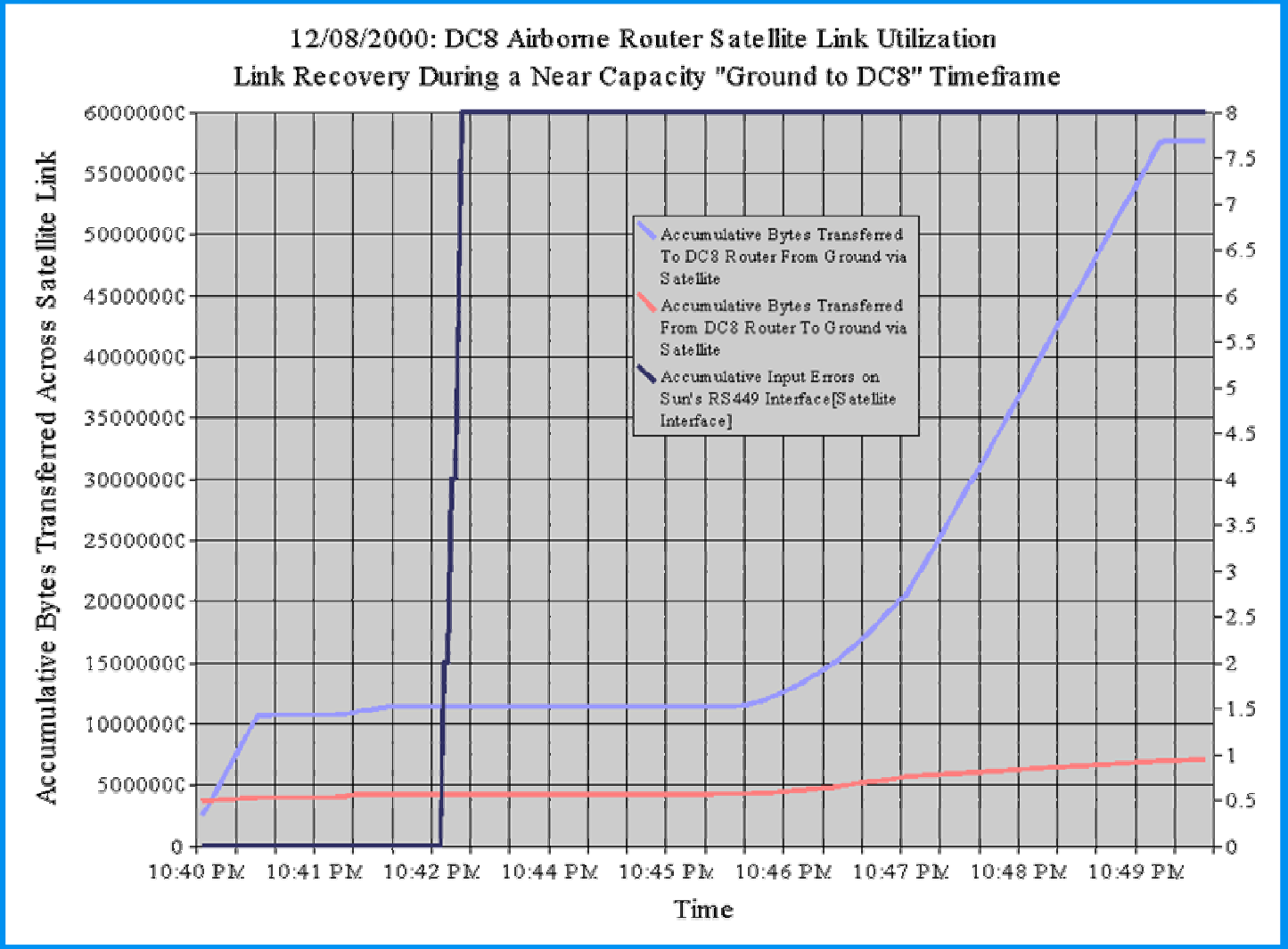
Antenna Performance



Link Recovery



Network Recovery



NASA LaRC's B757 for AWIN/WinComm

B757 flights near Hampton, Virginia (April 2002)

- Supported LaRC and GRC mission IP connectivity for WINCOMM, AWIN and AC/ATM projects.
- Used a Cisco 3640 IP router on the aircraft to route between the aircraft and the fixed station.
- Achieved 256 kb/s transmit from, and 2.1 Mb/s receive, between NASA B757 and GRC using the Ku-band phase array.

What is coming up?

- Integrate the van into a Test Bed for IPv6 for Aeronautical Communications and Services research using NEMO mobile IPv6.

  Partners:

  - Eurocontrol
  - CNS, Inc
  - Cisco Systems, Inc
- Research how mobile platforms can interconnect to current and future ATC and aviation systems.